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The Exhalation of Ozone

by

Flowering Plants.

by

J. M. ANDERS, M.D., PH.D.

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THE EXHALATION OF OZONE BY FLOWERING PLANTS.

BY J. M. ANDERS, M.D., PH.D.

THAN ozone there is, perhaps, no more highly remarkable and perplexing substance. Nevertheless there is no substance more important to the sanitarian for study and consideration, since it has undoubted hygienic bearings, some of which are now quite well understood. There is no question but that through its oxydizing properties it is the greatest natural purifier of the atmosphere.

It is doubtless nature's means of ridding our atmosphere of organic impurities, and disease germs, which cause, as is well known, manifold forms of suffering, and render the air unfit for breathing purposes.

We have little certain knowledge of its real nature and many of its properties; and leaving the solution of these more puzzling questions to the expert chemist, I purpose to adduce evidence with a view of establishing a newly-discovered source in nature of this important substance.

Ozone can be artificially formed in various ways, to wit: by passing electric discharges through pure oxygen; by the electrolytic decomposition of water; by suspending a stick of phosphorus in a bottle filled with moist air, and in other ways. It is present in the atmosphere, but not universally. Fresh, pure atmosphere generally contains ozone, while it is absent from the close air of cities and occupied dwellings, for the reason that in the latter places it is consumed in oxydizing and destroying organic impurities. For a like reason it is frequently found in the air to the windward of a city, but rarely or never to the leeward.

In my readings, while preparing earlier memoirs on some plant functions, I would not infrequently meet with statements to the effect that some sort of relationship exists between vegetation, and particularly forest growth, and the ozonic condition of the atmosphere. Thus, as stated in a former paper, a Dr. Schreiber maintains that the emanations from pine forests actively convert the oxygen of the air into ozone, but upon what basis of truth, if any, the statement rests, I have not learned. A. Naquet says, "Ozone exists in woods and fields and wherever there is active vegetation." It is evident that assertions of a general character like the above, without experimental proof, are of no real scientific value. On the other hand, the solution of so important a question as whether plants generate or convert the oxygen of the air into ozone, could not fail to be hailed as a noteworthy advance in scientific knowledge.

For more than a year past the writer, while engaged in the active practice of his profession, has devoted his intervals of leisure to an experimental investigation of the subject. Preliminary to giving in detail the results of these experiments, it is thought proper to speak of the various tests for the detection of ozone, and to point out the relative merits of the same. As indicative of the difficulties of making such tests, numerous ozonoscopes have from time to time been devised, most of which have proved highly unsatisfactory.

Dr. A. R. Leeds, of Stevens Institute of Technology, has made an investigation into the relative merits of some half dozen leading tests for ozone (*Chem. News* for May, 1878). Without giving a detailed account of his observations, it will suffice our purpose to state a few of his conclusions. The Schoenbein or oxydized starch test was found to be most sensitive. It may be here stated that this test was used in all my observations. Of the guaiacum test, which was also employed in our experiments, Dr. Leeds remarks, "Guaiacum papers were only moderately sensitive, acquiring speedily, when dry, a faint blue color, and when moistened occupying a position midway between the ozonoscopes most sensitive, and those least so to the influence of ozone."

In the National Board of Health Bulletin (for March, 1882), Dr. J. H. Long, under the auspices of the American Medical Association, records the results of ozone observations made in different places throughout the United States, by a number of gentle-

men who kindly coöperated with him. In these investigations three kinds of tests were employed, to wit: Schoenbein paper, paper impregnated with tincture of guaiacum, and paper impregnated with solution of thallous hydrate. The doctor gives the methods of preparing these different papers. The Schoenbein is made according to the following formula: Potassium iodide 5 parts, starch 50 parts and water 1000 parts. The starch and iodide are rubbed with a small amount of water until a milky homogeneous fluid is produced, and then the rest of the water is added and the whole boiled for some time with constant stirring. The freshly prepared paste is spread on strips of filter paper, which are afterwards dried in a close room. The filter paper used is the best Swedish (Munktells). The guaiacum is made from a carefully prepared tincture containing 8 per cent of resin and 90 per cent of alcohol. When exposed to artificially prepared ozone this paper turns greenish-blue and finally a bright blue, while the Schoenbein turns quite blue. The papers employed in the present researches were very kindly prepared for me by Professor Henry Leffman after the above formulæ, and they gave excellent reactions both in the hands of the professor and in my own hands, when exposed to ozone artificially prepared. The iodized starch, or Schoenbein, being universally acknowledged to be the most sensitive, as well as giving the most reliable results, the reactions obtained by this test were considered of paramount importance and value. There are, however, sometimes other bodies present in the atmosphere which have the power of decomposing iodide of potassium, and hence give a blue reaction as well as ozone, to wit, peroxide of hydrogen, the oxides of nitrogen and ammonia. The latter substance can be detected by suspending a piece of red litmus near to the test papers, the effect being to turn the paper blue. The presence of the nitrous oxides can also be readily demonstrated. How to avoid mistaking the reaction of peroxide of hydrogen for ozone may prove difficult, since the two substances appear to have many properties in common. Indeed, it has been a disputed question among chemists whether it is possible to distinguish between them by any known tests. Professor A. R. Leeds (*Chem. News* for April 9, 1880) claims to be able to recognize each by its own properties. He continues, "The most striking property of ozone is its smell. This smell, so far as long continued familiarity with it enables me

to judge, whether the ozone is derived from the silent discharges of pure and dry oxygen, or accompanies the electrolysis of water (and the smell is identical), is possessed by ozone only." This odor is not peculiar to peroxide of hydrogen, for the same author says of this substance, "The solution which I have prepared at different times myself, carbonic acid being employed to decompose barium peroxide, have not evolved any odor that I was able to recognize or perceive. Ozone is only slightly soluble in water, and is readily expelled on heating, while hydrogen peroxide is mixable, and solutions containing one per cent of peroxide of hydrogen may be concentrated by evaporation on the water bath until a higher degree of concentration is reached without great loss of peroxide."[1]

The question, can ozone and peroxide of hydrogen coëxist in the same atmosphere? has also been oppositely discussed by chemists. Professor McLeod, as the result of his investigations (*Chem. News*, Vol. XL, p. 307), concluded that these two bodies decompose one another. From this fact he further argues that it is extremely improbable that ozone and peroxide of hydrogen are both formed during the slow oxydation of phosphorus. On the other hand Schöne, by an elaborate series of experiments (quoted by Leeds) shows that when strongly oxydized oxygen, containing 5.2 volumes per cent of ozone, is agitated with an hydrogen peroxide solution containing 0.4 per cent of the peroxide, or three or four times as much as is necessary to destroy all the ozone, it is only after the lapse of half an hour that as much as half of the ozone is destroyed. Professor Leeds, in the article already referred to, comes to the rescue of Schöne, and very conclusively shows that not only ozone but also peroxide of hydrogen are formed during the slow oxydation of phosphorus, and that those two substances can and frequently do coëxist, the absolute quantity depending upon the temperature, the length of time they remain in contact with one another, etc., though it is true that a slow, mutual decomposition takes place when together. According to all the best authorities, peroxide of hydrogen decomposes at a temperature of about 70° Fahr., while to destroy ozone requires a temperature of about 200° Fahr. The importance of this fact cannot be overrated, as it has a great bearing upon the results of the present experiments.

[1] See also Schöne, Ann. der Chem., 196, p. 60, and Davis, *Chem. News*, Vo XXIV, p. 221.

In the case of the guaiacum test there are so many interfering conditions as to render it nearly valueless. Thus it will not only react in the presence of peroxide of hydrogen and the oxides of nitrogen, but even the oxygen of the atmosphere is said to impart to it a tint hard to distinguish from the coloration due to ozone.

The color scales were not used in these researches, as they are very difficult to obtain and, furthermore, the object here was not so much to ascertain the degree of coloring of the test papers as the single important fact whether plants have the power of generating ozone.

In noting the results obtained, the terms "marked," "slight" and "very slight" are used to express, in a general way, the extent of blue coloration. This plan is deemed preferable for the reason that the tints, in most instances, were not very striking.

My first observations were conducted in Horticultural Hall, Fairmount Park, Philadelphia. It was thought that a careful testing of the air of this hall, filled as it is with a profusion of plants, mostly of the foliage varieties, would give results sufficiently striking to be of value in clearing up the subject. In this, however, I was measurably disappointed, as will be seen hereafter. The hall has several compartments. The so-called main hall, of about the following dimensions: 220 feet in length, 100 feet in width and, the dome-like roof being of glass in the center, 65 feet high. The room is filled with a variety of species of palms, bananas, monesteras, colocasias, caladiums, ferns, *Ficus elastica*, bamboo canes, Australian and New Zealand pines and numbers of smaller foliage plants. Average temperature of the hall during the time of experiments, 70° Fahr.

On either side of the main hall are several smaller ones in which the air was likewise tested, known under the names fern house, forcing house, temperate house, propagating house and economic house. The dimensions of these rooms are, length 100 feet, width 30 feet, ceiling, curvilinear and of glass, 20 feet in height. The temperate house contained half hardy plants, as the orange, lemon, hibiscus, and a number of azalias in bloom. The forcing house contained bedding plants, geranium, colius and achyranthes, but few blooming, mostly cuttings. Economic house contained pitcher plants, tea, coffee, chocolate, sugar, yapas, cinchona and aromatic plants. Propagating house is located outside of the main building, and contained geraniums in bloom. The fern house was well stocked with ferns.

The average temperature of these apartments was as follows: Economic house 80°, temperate house 55°, fern house 65°, forcing-house 75° Fahr.

The first experiments were commenced Oct. 14, 1882, and continued till the end of November. The atmosphere of the main hall was tested on twenty-five days during this period, the Schoenbein giving negative results except on Nov. 29th and 30th, when this paper showed a slight blue tint. The papers were placed on the branches of the highest plants, moistened both when they were suspended and after being taken down, and the duration of the experiments varied from four to twenty-four hours.

The guaiacum test paper showed a very slight reaction for about one-half of these observations, but unfortunately this test could not be relied upon, while the results with the Schoenbein were too meager on which to base conclusions. A few tests were made during this series simultaneously in the forcing and fern houses with negative results. It should be stated that these experiments were being conducted at a time when numerous visitors were daily attracted to the hall by the indescribable beauty of the plants, and hence it was thought not unreasonable to suppose that any ozone which might have been generated by the plants was consumed in oxydizing the organic matter given to the air by the visitors, for it should be remembered that, as Pettenkofer has pointed out, ozone is never detectable in the atmosphere of occupied dwellings. Though these experiments were barren of results, when the above circumstances are taken into account they were not much to be wondered at.

The next series of observations began in the latter part of February, and were continued through the months of March and April of the past year. During the month of February there was only an occasional visitor admitted, in March there were likewise very few, while in April the number was considerably greater, though not by any means numerous. These experiments yielded results somewhat more encouraging. The atmosphere on the exterior was simultaneously tested for the sake of comparison in the two situations. The observations were taken for fourteen days in the main hall, Schoenbein papers being used, and five of these gave "very slight" reactions, while the outer air gave during the same time six "very slight" reactions and one "slight." Twenty-four tests of the air in the temperate house with the

Schoenbein gave only three "very slight" reactions. During these observations the outer air was tested twelve times, with but two "slight" reactions, and the air of the propagating house for the remaining days in place of the outer air, which gave two "very slight" reactions. The air of the propagating house was next compared with the external air. For thirteen days in the former situation the Schoenbein paper gave "very slight" reactions in four instances, while the latter (outer air) gave "very slight" indications of ozone in two instances. It will be observed that here the result was better in the propagating house than in the open air, which was, to say the least, quite suggestive. In all the preceding experiments of this series there was a striking similarity in the two situations, and the outer air giving somewhat the better results. The air of the fern house, as well as economic house, were also given a few trials and compared with the outer air, but the results were negative throughout. During all of the outdoor observations the guaiacum paper gave slight indications of ozone in more than half of the experiments, and striking in four cases. The results with this paper for corresponding days indoors were almost identical, with the degree of coloring in a few instances in favor of the outside. The propagating house yielded the best indoor results with the guaiacum paper, as did the Schoenbein, while the temperate house gave almost equally good results with the guaiacum paper as in the propagating house. This was not the case, it will be remembered, with the Schoenbein. The duration of the individual experiments varied from six to sixteen hours, the average duration being about ten hours.

The question here arises, were the reactions obtained by the indoor tests due to ozone emitted from the plants or to the circulation of the outer air through these apartments. There is constantly more or less interchange of air between the exterior and interior of the building, due to the numerous interstices between the panes of glass and the frequent opening and closing of the doors. It must also be observed that all these apartments are heated (and artificial heat was necessary during all these investigations) by numerous hot water pipes placed directly under and parallel with a grated floor from which warm air rises and ascends through the building. The idea that the external conditions might have affected the results on the inside is doubtless still further strengthened by the fact that most of the results obtained

were, as already stated, nearly identical in the two situations, with a preponderance of coloring in favor of the outside. I was thus forced, though reluctantly, to dismiss all the experiments thus far made as having yielded doubtful results, excepting those made in the propagating house, of which it will be necessary to speak further.[1]

How can we account for the results in this situation differing from those of the other rooms? I was unable at that time to find any good reason, the conditions appearing to be about the same. Subsequent experimentation, however, threw new light upon this vexed question. It will be only necessary here to state, what I trust will be evident to the mind of the reader later on, that the somewhat more striking results in this house must have been due to the fact that it was well stocked with flowering geraniums.

(*From the American Naturalist, May, 1884.*)

THE EXHALATION OF OZONE BY FLOWERING PLANTS.

BY J. M. ANDERS, M.D., PH.D.

(Continued from page 344.)

IT became evident that in order that this important question might be set at rest, the conditions would have to be varied and further observations instituted. I now set to work to devise the necessary apparatus to carry on such experiments. Accordingly I had made a glass case large enough to contain a dozen or more thrifty growing plants in pots. Its dimensions were as follows: length, three and a half feet; width, two and a half feet, and height, two and a half feet. A portion of the top was left removable, so as to furnish an aperture through which the plants could be placed in the case and again taken out. Such an arrangement as this would admit the sunlight to the plants and confine their exhalations, and thus give the ozone, if any should be generated, a better opportunity of acting upon the test papers. In all of the remaining experiments here recorded I was greatly assisted by Mr. G. B. M. Miller, my medical student. The apparatus was first placed in the bay window of an occupied sitting-room facing east. The plants here received the sun's rays for at least six hours of the day. A dozen thrifty plants were placed in the

[1] My acknowledgments are due Mr. Menje for valuable assistance while conducting these observations.

case, which was then accurately closed by the removable piece of glass already spoken of; the test papers having been moistened and tacked on the branches or stems of the plants. In the first series of experiments flowering plants were used, twelve in number, each having several flowers and about four square feet of leaf surface. They consisted of varieties of geraniums, fuchias, begonias, hydrangeas and petunias. Upon these plants eighteen observations were made of about four hours each, during the latter part of the month of May, 1883; weather mostly fair. The Schoenbein showed "very slight" indications for seven of the experiments and one "slight" coloration, there being ten negative results. The guaiacum papers gave more striking results, the change in the papers being marked for ten of the experiments and slight for the remaining trials, save one which was negative. Great care was taken to keep the plants experimented with in a healthy condition; they were also left in the pots in which they had been grown. There are two reasons which can be assigned why the results in these experiments were not very striking with the iodized starch test First, the experiments were of too short duratio n; and secondly they were conducted indoors, for the air of the case was originally the air of the room, and a portion at least of the ozone which might have been generated by the plants would have been decomposed by the impurities of the air in the case.

With a full knowledge of the very unfavorable conditions under which these experiments were conducted, but encouraged by their moderate success, it was resolved to make a trial of odoriferous flowering plants under the same conditions. Again our little floral chamber was filled with plants, consisting of seven rose bushes, four carnation pinks, and six heliotropes. The duration of observations about ten diurnal hours each; weather mostly clear, two days cloudy. With the Schoenbein test there were "very slight" reactions in most instances, two "slight" and one well "marked," while the guaiacum papers were "marked" in most cases, a couple being "slight." The number of experiments were eight. These investigations suggested the idea naturally that odorous flowering plants might be better ozone generators than inodorous ones. The external atmospheric conditions were very similar during the time of both the preceding sets of experiments, the maximum temperature ranging

from 85 to 88° Fahr. Repeated testing of the atmosphere of the room in which the case was situated gave no indications of the presence of ozone.

The question now very naturally arose whether the colorations were due to ozone or to some of the substances which give the same reactions with these papers; hence, further investigation was necessary in order to exclude, if possible, these interfering conditions, before it could be claimed for plants that they were capable of emitting or converting the oxygen of the air into ozone. It was also deemed important to conduct future experiments out of doors as, for reasons already given, it was expected more decided results would be obtained. The case was removed to the back yard, which lies to the eastward of the dwelling. Here the plants received the sunlight for at least eight hours daily during clear weather, and the yard was of good size. In the first series of experiments in this locality the plants last named were employed.

After observations for seven consecutive days of clear weather the Schoenbein paper gave "slight" reactions in four cases and "marked" reactions in three. The guaiacum paper gave "slight" indications in three and "marked" in four experiments. It will be seen that these experiments gave more marked results than those made within doors. It may be stated that it was found that the coloration of the Schoenbein or iodized starch test was "slight" instead of "very slight" as indoors, and in three cases actually "marked," against one "marked" result in the preceding series. The guaiacum tests were nearly correspondingly more marked. It is probable that the more surprising results of the last series are not attributable solely to the change of location, but also in some degree to the fact that the experiments were of longer duration. A piece of red litmus suspended in the case during these experiments gave no indication of the presence of ammonia. Peroxides of hydrogen could not have been the reactionary agent, since that substance is decomposed at a temperature of 70° Fahr., while the temperature of the atmosphere within the case, which was carefully noted, was never found below 90° Fahr. These observations were made during the first week in June, 1883, the weather being very warm and the temperature of the air within the case being higher than that of the external air. Good reactions were, however, obtained in later experiments,

when the temperature did not mark over 70° Fahr. That the reactions were not due to the nitrous oxides, perhaps the only remaining substances capable of producing like colorations of these test papers, will appear evident hereafter.

It was next proposed to give foliage plants having soft thin leaves a trial. Seven asperdisteus, one fern and three dracænas were chosen for experimentation. These observations were conducted during the first week in September, 1883, for seven consecutive days. The weather was extremely warm, the temperature of the air within the case ranging from 85 to 100° Fahr., the sky was clear during four days and partly cloudy the remaining three. The Schoenbein test paper gave negative results throughout, while the guaiacum gave one "very slight" reaction, the rest being negative also. Thus it would appear that foliage plants have not this power of generating ozone, the function must therefore reside with the flower, but of its nature we shall speak hereafter.

As our first experiments with inodorous flowering plants did not yield results striking enough to afford a basis for positive conclusions, it was considered desirable to apply the tests to them in the open air, which was done. Seventeen thrifty geraniums were employed. The temperature was lower during these experiments than during those made indoors with inodorous plants. For six consecutive days, experiments being of ten hours each duration, the Schoenbein gave one negative, two "slight" and three "marked" blue shades. The negative result occurred upon a rainy day, during which there was no sunshine whatever. This would indicate that sunlight, or at least good diffused light, is essential to the generation of ozone by plants, for the plants were protected from the rain by the glass. There are other physiological processes carried on by plants which are almost entirely dependent upon the power of the sun's rays, *e. g.*, assimilation and transpiration. To the above may doubtless be added the development of ozone.

Observations were continued upon these plants during the second week of September, the result being about similar to those last noted, the Schoenbein gave two "marked," one negative, on a rainy day, and the rest "slight" reactions. The guaiacum papers gave two "striking" and the rest "slight" colorations. As already intimated nitrous oxides, which are present in the air,

change the color of these test papers very much as ozone does. To exclude the possibility of the change in color being due to the nitrous oxides, we tested the air during the latter set of experiments on the outside of the case simultaneously, and found that the papers in this situation gave only one "slight" reaction, and even though this occasional reaction on the exterior had been due to the presence of the nitrous oxides, they could not have caused the much more striking and constant tests obtained on the inside. Again, it is not at all likely that the plants generated nitrous oxides, which in turn might have changed the test papers, for there is nothing in all vegetable physiology to support such an hypothesis. Moreover, it is all the more improbable that nitrous oxides caused the blue colorations, since they did not do so *when foliage plants were employed.*

We do not wish to say dogmatically that all the changes in the test papers were due to ozone, but from the many beautiful reactions obtained, and the systematic precautions taken to preclude the action of other substances known to answer to like tests, it will not be denied that the chief agent in changing the papers was ozone. I was unable to detect the odor of ozone upon which Professor Leeds lays so much stress, but Mr. Miller thought he could detect its presence. It must be borne in mind that the amount of plant life within the case was probably too small to generate sufficient ozone to make it perceptible to the sense of smell.

It would appear certain from these experiments, that the leaves which are so actively engaged in carrying on the important functions, as, for example, transpiration, have nothing whatever to do with the production of ozone. But, on the other hand, it is to the flower that is delegated this highly important, though perhaps hitherto unthought of, function in plant life.

Can we, from the facts derived from these observations, come to any definite conclusions respecting the nature of this function? Is the cause to be sought in the functions of the petals or in the formation of the seed? Let us here recall how ozone can be produced artificially, and it will be remembered that one mode is by suspending phosphorus in moist air. Now it is known that the ashes of seeds contains large quantities of the phosphates. It follows that during the formation of the seeds there is a rapid metastasis of phosphorites in the form of phosphoric acid and

the phosphates to that organ of the plant, and it may reasonably be supposed that in the chemico-vital changes going on in the ovules, phosphorus is liberated and acted upon by the moisture which the leaves and petals are so actively transpiring.

As corroborating this view we may allude to the phenomena of phosphorescence in plants as observed by M. Crié and others. In a communication to the French Academy, M. Crié states: "It is well known that the flowers of phanerogams are capable, under certain circumstances, of producing phosphorescent light. The phenomenon has been verified, especially of the nasturtiums and the marigold. Some years ago I myself saw phosphorescent light emitted in stormy weather from the flowers of the *Tropeolum majus* cultivated in a garden." Although an absolute decision may not be possible, the above facts, when taken together, are suggestive of the correctness of this explanation. The subject, however, merits further investigation.

In the light of the present experiments there can scarce be a doubt but that a manifest relation does exist between vegetation and the ozonic condition of the atmosphere. And this, it will be conceded, is not the least hygienic influence possessed by plants. During fair weather all flowering vegetation in nature is contributing ozone to the atmosphere. In this connection it should be borne in mind that vegetation is largely blooming, that numerous field plants, the forest trees, as well as all fruit trees put forth flowers, and that during this period they all add their quota of ozone to the surrounding medium. Again, not all blooming plants or trees produce their flowers at the same time of the season, so that it happens that there are a certain proportion of different species flowering in turn from early spring till late in autumn, and hence the effect upon the atmosphere with reference to the amount of ozone they give to it must be pretty constant during the whole vegetative period wherever vegetation abounds. We here have another evidence of the fact that in His eternal wisdom the Author of nature has intrusted to plant life the task of maintaining the harmonious composition of the atmosphere. A certain proportion of ozone in the atmosphere is essential to prevent it from becoming too much polluted for animal respiration by the products of decomposition, particularly of azotized substances, which are known to be a fruitful cause of disease, and which are believed by some to serve as carriers for the germs of epidemic and contagious diseases.

Upon this point Professor Kedzie observes: "I call ozone the most energetic of the constituents of the atmosphere. Its presence or absence must have a *controlling influence over the vital powers.* And when we consider that this material is present in such variable amount in a medium which enfolds us every moment of our lives, and where action 'pauses not for matin or for vesper, at noon of day or noon of night,' it seems to me that no one can deny that its influence on human health must be most significant."

Professor Max von Pettenkofer says of the hygienic value of ozone in the air: "It is the constant purifier of the atmosphere from all organic matter which passes into it and might accumulate. The air would have been long ago filled with the vapors of decomposition if it were not for ozone, which oxydizes all that is oxydizable, if only time be allowed for it and too much is not expected at once."[1]

How long it would be possible for animal life to exist were all the atmospheric ozone to be suddenly annihilated, cannot be computed; but that existence would sooner or later become impossible on account of noxious substances which would accumulate in the air, and which it is the office of the ozone to destroy, cannot be reasonably doubted. How infinitely wise and beneficent, then, is the Author of nature in placing beside these destroying elements the means of reparation. And as flowering plants serve as natural ozone generators, they must be looked upon as worthy of being placed in the front rank as hygienic agents.

Perhaps the most interesting phase of this question is the application of the results of our observations to the beneficial effects of the cultivation of plants in dwellings. As already incidentally mentioned, ozone is not detectable in living rooms for the reason that it is decomposed in oxydizing the organic matter present. It was also seen that flowering plants generate ozone indoors during clear weather, and if a dozen thrifty plants, in a case of the dimensions of the one employed, give us a reaction, then it will not be doubted that a living room well stocked with flowering plants would give off sufficient to be of hygienic value, since it is well known that we rarely or never find but a small quantity in the external air, which yet serves to maintain it in a salubrious condition. The air of dwellings is very generally charged with

[1] *Popular Science Monthly*, Feb., 1878.

deleterious substances due to human respiration, insufficient ventilation, the presence of sewer gases, and many other causes. That the hygienic conditions of the air of living rooms is almost universally abominable is admitted by the best authorities, and it is also true that this bad air of our dwellings serves admirably as a culture fluid for the various disease-producing germs. How to obviate the ill effects arising from this unfortunate condition of things is a question of paramount importance. Since plants are capable of generating ozone, which has the power of destroying not only the organic impurities but even disease germs, it follows that the requisite amount of flowering plants grown in our living rooms would, in a great measure, rid the air of these deleterious substances. From these observations it will readily be conceded that the value of house-plants as hygienic agents can scarcely be overrated. That no possible objection can be urged against the practice of keeping blooming plants in our living rooms (excepting in the case of those having pronounced odors, as the tuberose, etc.) has been shown conclusively elsewhere, and the old time prejudice, we are happy to be able to state, is rapidly dying out.

Shall we discard the foliage varieties because they are incapable of producing ozone? By no means; there are also important advantages to be derived from their presence. Not to speak of their æsthetic influence, there is, as already pointed out, confided to the leaf the important function of transpiration or exhalation of watery vapor. This process is carried on so actively by leafy plants as to give them the power to raise the degree of humidity of a closed apartment which is usually far below the health standard, as the writer has shown in previous articles.[1] It simply remains to be said that, in view of these experiments, the flowering treasures of the green-house as well as foliage plants should be welcomed into every household as being among our noblest sanitary agents.

[1] "Transpiration of Plants," AMER. NAT. for March, 1879; also "Beneficent Influence of House Plants," AMER. NAT. for Dec., 1879; also "Hygienic and Therapeutic Relations of House Plants," *Phila. Med. Times* for May 8, 1880.